

The Pseudoscorpionida of Hawaii Part I. Introduction and Chthonioidea

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Abstract. The history of our knowledge of pseudoscorpions in the Hawaiian Islands is traced briefly. The chthonioid pseudoscorpions already known to exist in the islands are reviewed and some additional records are reported. A new genus, *Vulcanochthonius*, is proposed, based on *Tyrannochthonius howarthi* Muchmore. Three new species are described: *Tyrannochthonius oahuensis* from Oahu, and *Vulcanochthonius aa* and *V. pohakuloae* from Hawaii Island. *Chthonius tetrachelatus* (Preysler) and *Lechytia sakagamii* Morikawa are reported for the first time and complete descriptions of the Hawaiian material are given.

Pseudoscorpions have been known on the Hawaiian Islands for about 100 years, but knowledge about them has been very scanty until quite recently. The first pseudoscorpion species recorded from the islands was collected on Laysan Island by H. Schauinsland during a voyage around the Pacific (1896–1897), and was described by E. Simon in 1899 as *Chelifer laysanensis*. About the same time, in the Arachnida section of “Fauna Hawaiiensis”, Simon (1900) reported the occurrence of two other pseudoscorpions, *Chelifer bifissus* Simon (originally described from Sumatra) and *Amblyolpium longiventer* (Keyserling) (originally described from Australia), both from Hawaii Island; in addition, he described two new species, *Chelifer hawaiiensis* from Hawaii and Kauai Islands, and *Garypus personatus* from Oahu. C.J. With (1905) described *Chelifer pacificus*, “probably from Hawaii”; in 1906 he mentioned a “*Garypinus* n. sp. from Hawaii”, and in 1907 he described *Garypinus mirabilis* from Kau [district of Hawaii Island], based on a specimen wrongly identified by Simon (1900) as *Olpium longiventer* L. Koch. M. Beier (1932a, b) questioned the occurrence of *Xenolpium longiventer* (L. Koch) in Hawaii and tentatively accepted *Garypinus mirabilis* and *Geogarypus personatus*; he also erected the new genus *Eumecochernes* to accommodate *Chelifer hawaiiensis* and *Chelifer pacificus* and described *E. oceanicus* from Kauai Island (Also described in Beier 1933); and he transferred *Chelifer bifissus* to *Lophochernes* and tentatively placed *Chelifer laysanensis* in the same genus. In 1934, J.C. Chamberlin listed the known species, and named *Lophochernes cryptus*, based on the individual from Hawaii Island that Simon had identified as *Chelifer bifissus*. C.F. Roewer (1936–1940) listed the species, transferring *Chelifer laysanensis* to the genus *Allowithius*. Chamberlin (1938) described as new *Cheiridium* (*Cheiridium*) *simulacrum* from Oahu. A note by E.H. Bryan, Jr. (1939) reported the presence of *Lophochernes cryptus* on Kauai. Beier (1940) listed the species known from the Hawaiian Islands, transferring *Garypinus mirabilis* to the genus *Xenolpium*. A note by N.L.H. Krauss (1948) reported the occurrence of representatives of a *Withius* species “closely similar to, or identical with, *Withius subruber*” on Oahu, Maui, Kauai, and Hawaii Islands. As far as I know, no other report of pseudoscorpions in the Hawaiian Islands appeared until 1979, when I published the first of several papers based on material sent to me by F.G. Howarth and his colleagues; in these, I described four new species in the genus *Tyrannochthonius* — *T. howarthi* from a cave on Hawaii Island, *T. pupukeanus* from a cave on Oahu, *T. stonei* from a cave on Maui, and *T. swiftae* from an epigeal situation on Kauai (Muchmore 1979–1993).

During the past few years, I have received for study a goodly amount of Hawaiian material, from various sources. This includes representatives of one new genus and several new species, along with new records of known species. The results of this study will be published in three parts: the present paper deals with species in the superfamily Chthonioidea, the second will cover the Garypoidea and Olpioidea, and the third will treat the Cheliferoidea.

Methods

All of the material studied in this part is deposited in the Bishop Museum (BPBM). Most of the specimens have been dissected, cleared, and mounted in Canada balsam on microscope slides, generally following the procedure outlined in Hoff (1959) but using clove oil, rather than beechwood creosote, for clearing. They were studied and measured under a compound microscope, and were drawn from projected images.

A few abbreviations are used in the text, as follows: L = length; L/B = ratio, length/breadth; L/D = ratio, length/depth; m = microseta or dwarf seta; T = tactile seta.

Systematics

Superfamily **Chthonioidea** Daday

Chthonioidea Daday.— Harvey 1991:131; Harvey 1992:1399.

Family **Chthoniidae** Daday

Chthoniinae Daday 1888.

Chthoniidae Daday.— Hansen 1893; Harvey 1991:131 (complete synonymy to 1988); Harvey 1992:1399.

Genus ***Chthonius*** C. L. Koch

Chthonius C. L. Koch 1843; Beier 1963:19; Harvey 1991:143 (complete synonymy to 1988).

The genus is found naturally in Europe and North America, with one or a few species spread worldwide by humans.

Chthonius (Ephippiochthonius) tetrachelatus (Preyssler) (Figs. 1A–D)

Scorpio tetrachelatus Preyssler 1790.

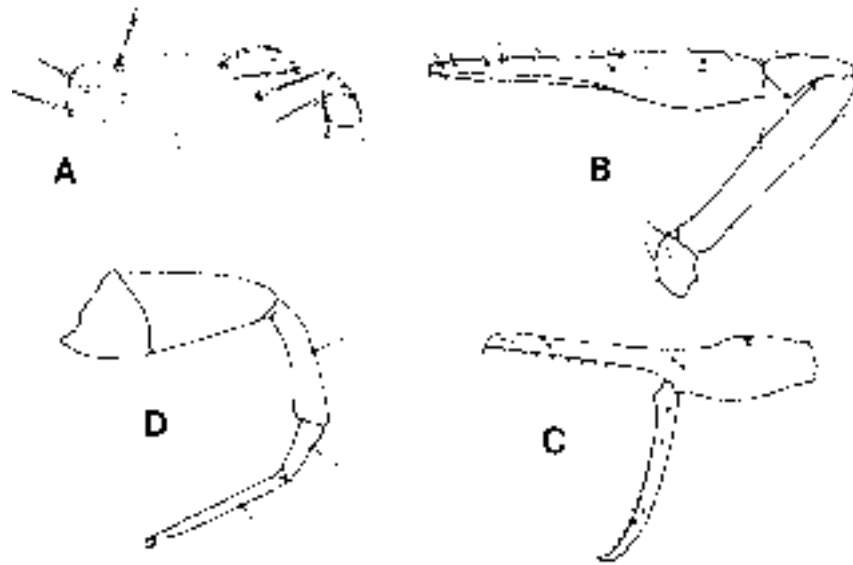
Chthonius tetrachelatus (Preyssler): Harvey 1987:68.

Chthonius (Ephippiochthonius) tetrachelatus (Preyssler): Harvey 1991:172 (complete synonymy to 1988).

Chthonius tetrachelatus has been reported from most countries in Europe and the Middle East, from the eastern United States, and from such farflung localities around the world as Argentina, Australia, and the Seychelles (see Harvey 1991). It has been termed a cosmopolitan species, under the assumption that it is synanthropic and is carried from place to place by humans. Its presence in Hawaii is, therefore, not surprising in view of the large scale importation of plants and accompanying soil that has occurred over the years.

As reported in the literature, *Chthonius tetrachelatus* appears as a very variable species (see Vachon 1941; Curcic 1972; Callaini 1984; Legg 1987). Harvey, while recording it in Australia, commented reasonably that “the possibility exists that more than one species has been confused under this name.” (1987:69). The specimens from Hawaii are recorded here *sensu* Harvey, recognizing that they may not actually be *Chthonius (Ephippiochthonius) tetrachelatus* (Preyssler) but rather some very closely related species. They are undoubt-

Figure 1. *Chthonius* (*Ephippiochthonius*) *tetrachelatus*: A, setae on anterior margin of carapace of one male; B, right palp, dorsal view; C, left palpal chela, lateral view (setae omitted); D, leg IV (vestitural setae omitted).



edly aliens, as no species of *Chthonius* (*Ephippiochthonius*) has ever been found anywhere around the North Pacific Basin. Therefore, the solution to their true identity will have to come from Europe, which seems to be the center of distribution of the subgenus.

As Harvey (1987) did for his Australian material, selected features and measurements of the Hawaiian specimens are given below, in order to provide data for future comparisons.

Material examined. Hawaii: Hawaii Island, Mauna Loa Estates, 1100m, wet forest, under trash can by lawn, 25 II-1994, D. Foote, 2 males, 1 female; mounted on slides, in BPBM.

Description. Male smaller than female, and with more slender appendages. Carapace a little longer than broad; with 4 eyes, anterior pair corneate, posterior pair flat. Carapaceal chaetotaxy varied: basically it is mm4mm-6-4-2-2, as seen in 1 male, but the other male has an extra microseta (m) in the anterior row and an extra large seta in the 4th row (that is, mm4mmm-6-4-3-2), and the female has an extra microseta medially in the anterior row and 2 microsetae laterally in the posterior row (mm1m3mm-6-4-2-m2m); the large setae are heavy, lanceolate, while the microsetae are much shorter and proportionally thinner; in one of the males each of the 2 large medial setae on the anterior margin bears a small spinule on the side (Fig. 1A). Each coxa II with 7–11 and coxa III with 4 pinnate coxal spines; a bisetose intercoxal tubercle present between bases of coxae III (but one male with only one seta on intercoxal tubercle). Chaetotaxy of tergites 1–8 is 4:4:4:4:6:6:6:6 in two specimens (male and female), but 4:4:4:5:6:6:6:6 in the third (male). Cheliceral hand with 7 setae;

galea a distinct knob in both sexes; movable finger with a large distal tooth followed closely by 4 small ones, fixed finger with 6–7 close-set teeth of varied sizes. Palp (Fig. 1B): femur slender in both sexes, chela longer and more robust in female than in male; L/B of femur 6.0–6.4, patella 2.05–2.1, and chela 5.75–5.85 (m), 4.7 (f); L/D of hand 2.3–2.45 (m), 2.05 (f); movable finger L / hand L 1.35–1.4 (m), 1.25 (f). Dorsum of chelal hand with a distinct depression distad of middle (Fig. 1C), more pronounced in female than in male (characteristic of the subgenus *Ephippiochthonius*). Articular condyles of both fingers greatly thickened. Fixed finger of palpal chela with 18–21 teeth, and movable finger with 14–16. Positions of trichobothria typical (Fig. 1C). Leg IV (Fig. 1D) with L/D of femur+patella 2.3–2.4 and tibia 3.8–4.0.

Measurements (mm). Male (female): Body L 1.5 (2.3). Carapace L 0.41–0.42 (0.50). Chelicera L 0.33–0.34 (0.46). Palp: trochanter 0.155 (0.20) / 0.095–0.10 (0.125); femur 0.56–0.58 (0.69) / 0.09 (0.115); patella 0.215–0.22 (0.27) / 0.105 (0.13); chela 0.75–0.76 (0.92) / 0.13 (0.195); hand 0.32 (0.41) / 0.13–0.14 (0.20); movable finger L 0.435–0.445 (0.51). Leg IV: femur+patella 0.495–0.51 (0.60) / 0.215 (0.25); tibia 0.31–0.32 (0.38) / 0.08 (0.095).

Genus *Tyrannochthonius* Chamberlin

Tyrannochthonius Chamberlin 1929:74; Harvey 1991:205 (complete synonymy to 1988); Harvey 1992:1399; Muchmore and Chamberlin 1995:250.

The genus is tropicopolitan in distribution, with a few species found in temperate areas.

Recently, Muchmore and Chamberlin (1995) have reviewed the characters of *Tyrannochthonius*. Although that work was based on species in the eastern United States, the generic diagnosis is generally valid also for the species in Hawaii. The known Hawaiian species are uniform in the following particular characters: anterior margin of carapace with a microseta (m) in front of each eye, so that chaetotaxy of carapace may be given as m4m-4-4-2-2; chaetotaxy of tergites 9–12 is 5 or 6:4:T2T:0, rather than 7:4:T2T:0; on movable chelal finger, trichobothrium *sb* may lie midway between *st* and *b*, or closer to *b*; microdenticles on chelal fingers are reduced in both size and number.

Four species of *Tyrannochthonius* are known in the Hawaiian Islands, two on Oahu and one each on Kauai and Maui. It is especially interesting to note that none has yet been found on Hawaii Island, where three species of the related genus *Vulcanochthonius* occur (see below).

Tyrannochthonius pupukeanus Muchmore

Tyrannochthonius pupukeanus Muchmore, 1983:84, Figs 1–4; Harvey 1991:213 (complete synonymy to 1988); Nishida 1992:224.

Known only from the types (holotype female and numerous paratypes), collected in pit-fall traps in Pupukea Lava Tube, Pupukea, Oahu Island. Types in BPBM.

Tyrannochthonius stonei Muchmore

Tyrannochthonius stonei Muchmore, 1989:440, Figs. 1–2; Nishida 1992:224.

Known with certainty only from the holotype female, collected in KaluAuAu Dripping Cave, Ulupalukua, Maui Island. Type in BPBM.

A second specimen of *Tyrannochthonius* (also a female) is available from Maui, taken in a pitfall trap, at 3050 m elevation on Magnetic Peak, Haleakala National Park, by A.C. Medeiros. It is similar to the type of *T. stonei* in many respects, but it differs in other features, which suggest that it is less adapted to hypogean existence than *T. stonei*. Unfortunately, this specimen has at some time been dried and broken and several critical measurements are unavailable, so that it is not possible at present to recognize it as a separate species.

***Tyrannochthonius swiftae* Muchmore**

Tyrannochthonius swiftae Muchmore, 1993:180, Figs. 1–2.

Holotype male found in *Ohia* litter and soil, Hono O Na Pali NAR, Kauai Island. Type in BPBM.

A second male and a tritonymph were collected subsequently at the type locality by Dr. Swift. The male is, in all important respects, similar to the holotype. Several nymphs, probably of this species, were also found in *Ohia* litter and soil, Kuia NAR, Kauai I.

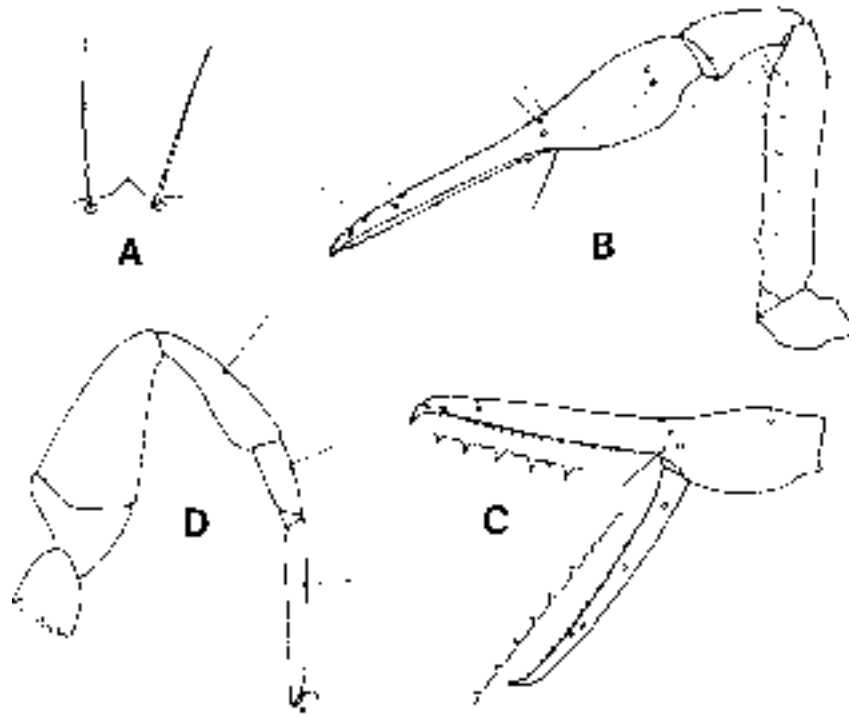
***Tyrannochthonius oahuanus*, new species (Figs. 2A–D)**

Type data. Holotype male (WM7813.01001) (BPBM 15607), allotype female (WM7813.01003), and 2 paratypes (male and tritonymph) from summit (960 m) of Puu Konahuanui, Koolau Range, Oahu Island, Hawaii, 27-VII-1991, G.A. Samuelson; adults mounted on slides, all in BPBM.

Diagnosis. About the same size as *T. swiftae*, from Kauai, but with appendages a little more slender (L/B of palpal femur of male = 4.7–4.75, rather than 4.4–4.5), usually with 5 setae (rather than 4) on tergite 5, and with a few (rather than no) microdenticles on the movable finger of the palpal chela. Compared with *T. pupukeanus*, also found on Oahu, *T. oahuanus* has more distinct, corneate eyes, less slender appendages (L/B of palpal femur = 4.65–4.75, rather than 4.8–5.15), and fewer (11 rather than 19–21) smaller, macrodenticles on the movable finger of the palpal chela.

Description. Representative of the genus as mentioned above, and with the following particular features. Female a little larger and more robust than male. Carapace, chelicerae and palps light brown, other parts tan. Carapace a little longer than broad; epistome small, triangular, with 2 setae closely flanking base (Fig. 2A); 4 distinct eyes, all corneate but posterior pair flatter; chaetotaxy m4m-4-4-2-2. Coxal area typical; coxa II with 6–8 terminally incised coxal spines. Tergal chaetotaxy of holotype 4:4:4:4:5:5:6:6:4:T2T:0, of allotype 4:4:4:5:5:5:5:6:4:T2T:0, of paratype 4:4:4:4:5:5:5:6:4:T2T:0. Sternal chaetotaxy of holotype (male) 9:[4–4]:(3)10–10/6(3):(3)6(3):9:9:9:9:6:0:2; anterior sternites of allotype (female) with 10:(3)8(3):(3)8(3):-. Chelicera 0.85 as long as carapace and 2.0–2.1x as long as broad; hand with 5 setae; flagellum of 8 setae; galea a very small elevation of finger margin. Palp rather slender (Fig. 2B): femur 1.2–1.25x and chela 1.75–1.8x as long as carapace. L/B of femur 4.65–4.75, patella 1.9–2.1, chela 5.1–5.35; L/D of hand 1.85–1.95; movable finger L / hand L 1.75–1.85. Trichobothriotaxy as shown in (Fig. 2C). One spine-like seta on medial side of chelal hand at base of fixed finger. Chelal fingers heterodont: macrodenticles (M) of fixed finger tall, sharp, those of movable finger lower, retrorse; microdenticles (m) very small, triangular; vestigial denticles (v) on movable finger low, rounded; fixed finger with 24–25 M, 10–15 m; movable finger with 11 M, 2–7 m, 12–13 v. Legs rather robust: leg IV (Fig. 2D) with L/D of femur+patella 2.4–2.65 and tibia 4.0–4.35.

Figure 2. *Tyrannochthonius oahuanus*, n. sp.: A, epistome and flanking setae; B, right palp, dorsal view; C, left palpal chela, lateral view (setae omitted); D, leg IV (vestitural setae omitted).



Measurements (mm). Figures given first for holotype male, followed in parentheses by those for allotype female and paratype male. Body L 1.33 (1.49, 1.33). Carapace L 0.41 (0.45, 0.40). Chelicera 0.34 (0.37, 0.34) / 0.16 (0.185, 0.16). Palp: trochanter 0.18 (0.19, 0.18) / 0.105 (0.115, 0.095); femur 0.50 (0.555, 0.495) / 0.105 (0.12, 0.105); patella 0.23 (0.235, 0.22) / 0.11 (0.125, 0.11); chela 0.74 (0.79, 0.725) / 0.14 (0.155, 0.135); hand 0.265 (0.295, 0.265) / 0.14 (0.16, 0.14); movable finger L 0.49 (0.51, 0.47). Leg IV: femur+patella 0.465 (0.495, 0.46) / 0.185 (0.185, 0.19); tibia 0.31 (0.325, 0.32) / 0.08 (0.075, 0.08).

Etymology. The species is named for Oahu, the island on which it is found.

Remarks. Both *T. oahuanus* and *T. pupukeanus* occur on Oahu, but they are well separated geographically and by habitat. The former is found in an epigeal situation on Puu Konahuanui, some 45 km southeast of and 900 m higher than Pupukea Lava Tube, the type locality of the latter.

Vulcanochthonius, new genus

Type species. *Tyrannochthonius howarthi* Muchmore (1979).

Diagnosis, based on females (males unknown).— A genus of the chthoniid tribe Tyrannochthoniini Chamberlin (1962), and distinguished by the following characteristics. Carapace longer than broad, slightly narrowed posteriorly. Epistome small, with closely flanking setae. Four or 2 eyes, the posterior pair poorly developed or absent. Chaetotaxy of carapace m4m-4-4-2-2. Apex of palpal coxa with 2 setae, the lateral one smaller and sinuous; coxa I with small, rounded anteromedial process; coxa II with an oblique row of 8–13 terminally incised coxal spines; intercoxal tubercle absent. Tergites 1–8 bordered by a row of large setae, 2–4 setae on segments 1–4, and 4–5 setae on segments 5–8. Chelicera large, about as long as carapace; 5 setae on hand; flagellum of about 8 pinnate setae; galea vestigial or absent; both fingers well provided with teeth. Palp typically chthoniid, long and slender (Fig. 3B); surfaces smooth, setae prominent. Trichobothriotaxy of chela as shown in Fig. 4B — on fixed finger *et*, *it* and *est* near distal end, *ist*, *esb* and *eb* at base; *ib* and *isb* on dorsum of hand proximad of middle; on movable finger *st* close to *t*, and *sb* closer to *st* than to *b*. Hand and fixed finger of chela with 2 conspicuous, very long and heavy setae on medial side at base, and movable finger with a similar, but smaller, seta near base. Both chelal fingers with a row of pointed teeth, spaced regularly along the margin; the teeth are largest in the middle of the row, becoming smaller distally and proximally; they vary somewhat in size, but the difference between adjacent teeth is small (no distinct macro- and microdenticles as seen in *Tyrannochthonius*). Legs long and slender; leg I with femur 1.8–2.0x as long as patella; legs III and IV with tactile setae on tibia and both tarsal segments.

Etymology. The genus is named *Vulcanochthonius* in recognition of the fact that its representatives are found on volcanoes.

Remarks. *Vulcanochthonius* can be considered a member of the tribe Tyrannochthoniini Chamberlin, which is characterized by the position of trichobothria *ib* and *isb*, transversely paired near or proximad of middle of dorsum of chelal hand; the occurrence of coxal spines only on the second pedal coxae; the lack of an intercoxal tubercle; the marginal teeth of the chelal fingers acute and well spaced; and, usually, the occurrence of one or more conspicuous, spine-like setae on the medial side of the chela. The tribe was established to include the genera *Tyrannochthonius* Chamberlin, *Lagynochthonius* Beier, *Paraliochthonius* Beier, *Troglochthonius* Beier, and *Morikawia* Chamberlin; subsequently, *Morikawia* was shown to be a synonym of *Paraliochthonius* (Muchmore 1972). Contrary to the statement of Harvey (1989: 21), the genus *Tyrannochthoniella* Beier (1966) probably does not belong here.

Superficially, *Vulcanochthonius* resembles *Troglochthonius* Beier (1939), based on *T. mirabilis* Beier, from a cave in southern Hercegovina, in Europe. However, the two genera are basically different, in that *Troglochthonius mirabilis* has 3 large, spine-like setae located on the fixed finger of the palpal chela, while the *Vulcanochthonius* species have only 2 such setae on the fixed finger, and also 1 on the base of the movable finger; it is unlikely that these species are congeneric. A second species was later assigned to *Troglochthonius*, namely, *T. doratodactylus* Helversen (1968), from Sardinia(?) and Trieste, Italy (see Mahnert 1980). This species is like *Vulcanochthonius* species in having 2 large setae on the fixed finger and 1 on the movable finger, but it differs in other important features, such as chaetotaxy of carapace, number of setae on tergites 1–4, and form of the teeth on palpal chelal fingers. In spite of any similarities between the Hawaiian and European species, it is inconceivable that the same troglomorphic genus could be represented in two locations halfway around the world. *Vulcanochthonius* must certainly have developed its adaptations to hypogean life independently of the European forms. And if this is so, it is remarkable that so much change has been accomplished in the short span of time available on Hawaii Island, less than one

million years according to Howarth and Mull (1992).

The origin of *Vulcanochthonius* is not clear. It undoubtedly came from a tyrannochthoniine stock, but whether from *Tyrannochthonius* or from *Paraliochthonius* is not apparent. With respect to the diagnostic characters mentioned by Muchmore (1984:124), *Vulcanochthonius* is similar to *Tyrannochthonius* in 1) the small epistome and closely flanking setae, and 2) the terminally incised coxal spines; but it is more like *Paraliochthonius* in 3) the chelal fingers with large, spaced macrodenticles and no microdenticles, 4) several very long and heavy setae on medial sides of chelal hand and fingers, and 5) movable finger with trichobothrium *sb* closer to *st* than to *b*. Further confusing the issue is the fact that though *Tyrannochthonius* is definitely well established on the Hawaiian Islands, no representative of *Paraliochthonius* has yet been found here (though it may occur along unexplored shores, as it is known from both Japan and western North America). In any event, *Vulcanochthonius*, with three species on the island of Hawaii, is sufficiently different from both *Tyrannochthonius* and *Paraliochthonius* to warrant generic status.

***Vulcanochthonius howarthi* (Muchmore), new combination**

Tyrannochthonius howarthi Muchmore 1979:187–189, Figs. 1–5; Harvey 1991:209 (complete synonymy); Nishida 1992:224.

Known only from 2 females, holotype and paratype, found in Petroglyph Cave, on the south slope of Kilauea, Hawaii Volcanoes National Park, Hawaii Island. Types in BPBM.

In the original description of this species, it was stated that both fingers of the palpal chela possess “occasional, very small denticles between the larger teeth.” (Muchmore 1979:187). However, reexamination of the types reveals that there are no true microdenticles between the macrodenticles, only occasional slight irregularities of the finger margin, as in *V. aa* (see Fig. 3C).

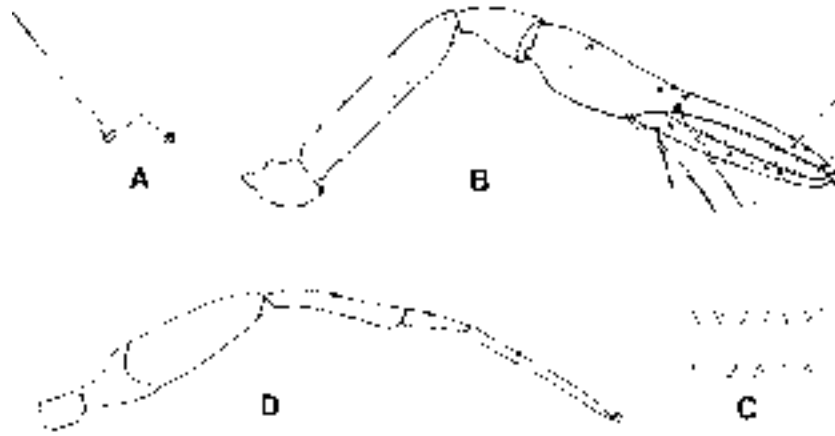
***Vulcanochthonius aa*, new species (Figs. 3A–D)**

Type data. Holotype female (WM7837.01001) (BPBM 15608) taken in a pitfall trap (baited with blue cheese and beer) buried 0.5 m deep in the moist rock zone within the surface clinker of bare a’a, near Visor Cave, 40 m elevation, Manuka Natural Area Reserve, S of Kona, Hawaii Island, Hawaii, 28 III 1991 to 11 V 1991, F.D. Stone; mounted on slide, in BPBM. Note: the right palpal chela is missing from the holotype.

Diagnosis. Similar to *V. howarthi*, but apparently less modified for hypogean existence — a little smaller, with 4 eyes rather than 2, less slender palps (L/B of chela 5.4 rather than 6.6–6.7), and with more setae on tergites (3 rather than 2 on tergites 1–2, and 5 rather than 4 on 7–8).

Description of female (male unknown). Representative of *Vulcanochthonius* as outlined above, and with the following particular features. Chelicerae and palps light tan, carapace and other parts straw colored. Carapace as broad as long; epistome small, triangular, denticulate at tip (Fig. 3A); 4 eyes, anterior pair corneate, posterior smaller and flat; chaetotaxy m4m-4-4-2-2. Each coxa II with a row of 8 or 9 terminally incised coxal spines. Abdomen typical. Tergal chaetotaxy 3:3:4:4:4:4:5:5:7:5:5:T2T:0. Sternal chaetotaxy 9:(3)4(3):(3)6(3):9:7:8:8:8:6:0:2. Chelicera 0.95 as long as carapace and 2.05x as long as broad; hand with 5 acuminate setae; flagellum of about 8 pinnate setae; galea a barely perceptible elevation of the finger margin. Palp rather long and slender (Fig. 3B). Femur 1.45x and chela 2.15x as long as carapace. L/B of trochanter 1.7, femur 5.45, patella 1.8,

Figure 3. *Vulcanochthonius aa*, n. sp.: A, epistome and flanking setae; B, left palp, dorsal view, chela twisted, showing medial side; C, teeth on chelal fingers, fixed finger above, movable finger below; D, leg IV (vestitural setae omitted).



chela 5.4; L/D of hand 1.95; movable finger L/hand L 1.75. Surfaces smooth. Trichobothria as shown in Fig. 3B. Two large, prominent, spine-like setae on medial side of base of fixed chelal finger and hand, and a similar, but smaller, seta on base of movable finger. Each finger with 25 tall, sharp, spaced, marginal teeth, large in middle of row and decreasing in size both distally and proximally; adjacent teeth vary somewhat in size, but there are no distinct alternating macrodenticles and microdenticles (Fig. 3C). Legs slender: leg IV (Fig. 3D) with L/D of femur+patella 3.6 and tibia 5.15.

Measurements (mm). Body L 1.33. Carapace L 0.415. Chelicera 0.39/0.19. Palp: trochanter 0.2/0.125; femur 0.60/0.11; patella 0.235/0.13; chela 0.89/0.165; hand 0.31/0.16; movable finger L 0.55. Leg IV: femur+patella 0.56/0.155; tibia 0.385/0.075; basitarsus 0.18/0.06; telotarsus 0.435/0.04.

Etymology. The specific name, *aa*, refers to the rough-surfaced lava, a'a, on which the type specimen was found; it is used as a noun in apposition.

Remarks. *Vulcanochthonius aa* was found beneath the surface of a'a, near sea level, on the southwest flank of the volcano, Mauna Loa, while *V. howarthi* is from Petroglyph Cave, some 80 km away and 600 m higher, on the south slope of Kilauea volcano. According to F.G. Howarth (in litt.), "By Hawaii standards, the two habitats are quite geographically separated — [by] two rift zones and older [lava] flows." Apparently, the distance and the forbidding terrain have provided sufficient isolation to allow differentiation of the two species.

Vulcanochthonius pohakuloae, new species (Figs. 4A–C)

Type data. Holotype female (WM8028.01001) (BPBM 15745) from deep zone of 10265-T40D Cave, 1600 m, Bobcat Trail, Pohakuloa Training Area, SW of Mauna Kea, Hawaii Island, Hawaii, 28 V 1995, F.G. Howarth and E. O'Toole; mounted on slide, in BPBM.

Diagnosis. Similar to *V. howarthi*, but with relatively larger and more slender palpal chela (chela L = 1.13 mm versus 0.96–1.04 mm; L/B of chela = 7.3 versus 6.6–6.7); however, palpal femur is about the same length but less slender (femur L = 0.74 mm versus 0.68–0.755 mm; L/B of femur = 6.0 versus 6.3–6.5); also with 4 rather than 2 or 3 setae on tergite 3.

Description of female (male unknown). Representative of *Vulcanochthonius* as outlined above, and with the following particular features. Palps and chelicerae light brown, carapace and legs tan, body lighter. Carapace longer than broad; epistome small, rounded rectangular (Fig. 4A); 2 small, flat eyes; chaetotaxy m4m-4-4-2-2. Each coxa II with a row of 10–13 terminally incised coxal spines. Tergal chaetotaxy 2:2:4:4:4:4:5:5:4:T2T:0; sternal chaetotaxy 8:(2)6(2):(2)6(3):8:7:7:7:8:0:2. Chelicera 0.95 as long as carapace and 2.15x as long as broad; hand with 5 setae; flagellum of 7–8 setae; no galea present. Palp long and slender (Fig. 4B). Femur 1.55x and chela 2.4x as long as carapace. L/B of trochanter 1.8, femur 6.0, patella 2.3, chela 7.3; L/D of hand 2.4; movable finger L / hand L 2.05. Trichobothria as shown in Fig. 4C. Two very long, heavy, spine-like setae on medial side of base of fixed finger, and 1 long, but much thinner, seta on base of movable finger. Fixed finger with 30 spaced marginal teeth, tall and sharp distally, becoming lower and triangular proximally; movable finger with 25 tall, spaced teeth distally, followed by 5 small, spaced denticles; there are no microdenticles interspersed between the large teeth. Legs moderately slender: leg IV with L/D of femur+patella 3.25 and tibia 5.85.

Measurements (mm). Body L 1.91. Carapace L 0.47. Chelicera 0.45/0.21. Palp: trochanter 0.235/0.13; femur 0.74/0.125; patella 0.325/0.14; chela 1.13/0.155; hand 0.37/0.155; movable finger L 0.75. Leg I: femur 0.45–0.065; patella 0.25–0.06. Leg IV: femur+patella 0.68/0.21; tibia 0.47/0.08; basitarsus 0.23/0.06; telotarsus 0.555/0.045.

Etymology. The species is named for its type locality, the Pohakuloa area of Hawaii Island.

Remarks. The cave where *V. pohakuloae* was collected is southwest of Mauna Kea, north of Mauna Loa, and northwest of Kilauea; it lies about 75 km from Petroglyph Cave (the type locality of *V. howarthi*) and a like distance from Visor Cave (the type locality of *V. aa*).

Family **Lechytiidae** Chamberlin

Lechyitini [sic] Chamberlin, 1929:76.

Lechytiidae Chamberlin: Harvey 1992:1402.

Genus **Lechytia** Balzan

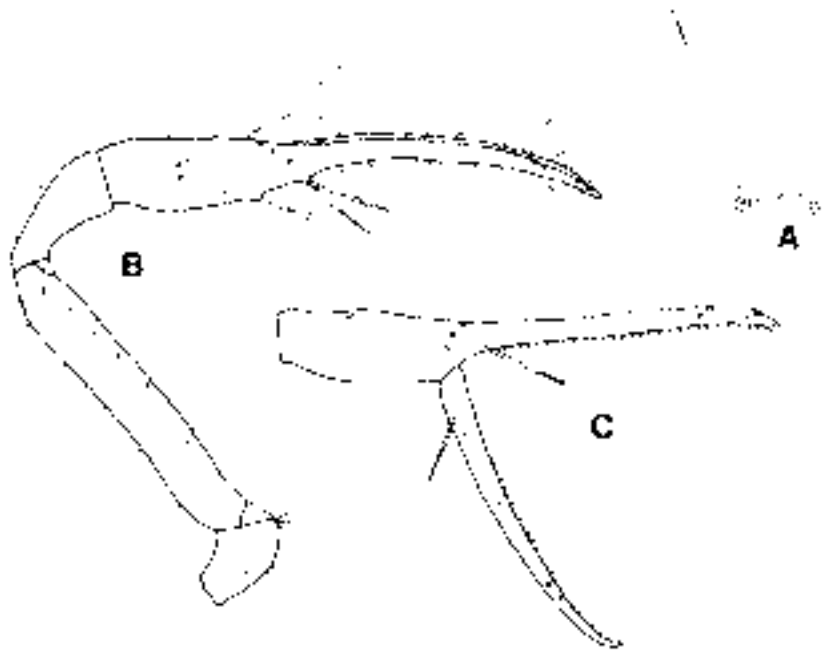
Lechytia Balzan 1892; Muchmore 1975:14; Harvey 1991:186 (complete synonymy to 1988); Harvey 1992:1402.

The genus is cosmopolitan in distribution.

Lechytia sakagamii Morikawa (Figs. 5 A–C)

Lechytia sakagamii Morikawa 1952:244, Figs. 3, 5B; Beier 1957:13, Fig. 3a; Morikawa 1960:111, pl. 2 Fig. 1, pl. 7 Fig. 10.

Figure 4. *Vulcanochthonius pohakuloae*, n. sp.: A, epistome and flanking setae; B, left palp, dorsal view; C, right palpal chela, lateral view (setae omitted).

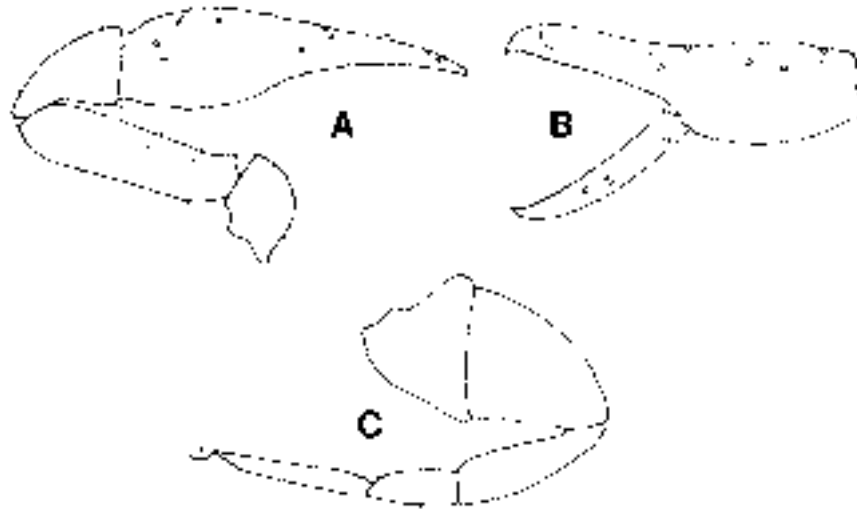


This species was described originally from Marcus Island in the northwest Pacific Ocean (Morikawa, 1952); later, Beier (1957) reported specimens from Ulithi in the western Caroline Islands, and Eniwetak and Taka in the Marshall Islands. Specimens at hand from Midway, Kauai, and Oahu in the Hawaiian Islands appear conspecific.

The original description of the species (Morikawa 1952), based on a single female, was rather brief and did not mention some important characters. Beier (1957) recorded only a few measurements of a single female (exact locality not given). It is possible that the specimens from Hawaii represent a different species, but information about the type of *L. sakagami* is not sufficient to allow satisfactory comparison. It seems appropriate to provide here a full description of the Hawaiian material, based on 9 mounted individuals.

Description. Generally typical of the genus (Muchmore 1975:14). Male and female similar, but female a little larger. Palps light brown, other parts tan. Carapace about as long as broad, slightly narrowed posteriorly; no epistome, but anterior margin slightly convex and denticulate; 2 small, faint eyes; chaetotaxy 6-4-4-2-2. Coxal area typical of genus, without coxal spines and intercoxal tubercle. Abdomen typical. Tergal chaetotaxy 6:6:6:6:6:6:6:6-

Figure 5. *Lechytia sakagamii*: A, left palp, dorsal view; B, left palpal chela, lateral view (setae omitted); C, leg IV (vestitural setae omitted).



7:4:1T2T1:0; lateralmost setae of anterior tergites slightly smaller than those more medial. Anterior sternal chaetotaxy of male about 10:[4-4]:(3)11-11/6(3):(3)8(3):-, setae lateral to genital opening furcate or dentate at tips; anterior sternal chaetotaxy of female about 8:(3)4(3):(3)9(3):-, setae lateral to genital opening furcate or dentate at tips. Chelicera 0.65-0.75 as long as carapace; hand with 5 setae; flagellum a row of 8 dentate setae, the second from distal end curved out of line; galea absent in male, a prominent protuberance in female. Palps robust (Fig. 5A); femur 0.8-0.9 and chela 1.25-1.35x as long as carapace. L/B of trochanter 1.55-1.75, femur 3.5-3.7, patella 1.65-1.7, and chela 3.6-3.9; L/D of hand 1.6-1.8; movable finger L/hand L 1.2-1.3. Surfaces smooth. Trichobothria typical, as shown in Fig. 5B: on movable finger, *st* and *sb* close together, only about half an areolar diameter apart. Each finger with 4-8 small teeth distally, followed by 12-15 very low, rounded elevations of the margin; fixed finger with a tiny accessory denticle on medial side at level of 2nd marginal tooth. Movable finger with a diploid sensillum midway between trichobothria *b* and *sb*. Legs rather robust; leg I with femur about 2x as long as patella; leg IV quite stout (Fig. 5C), L/D of femur+patella 1.8-1.95 and tibia 3.4-3.6. Telotarsi of legs I-IV with elongate pits, presumably glandular in nature, as reported by Judson (1992:76-77, Figs. 5.13A, C, D).

Measurements (mm). Ranges given for 4 males (4 females) from Oahu. Body L 0.96-1.07 (1.18-1.37). Carapace L 0.32-0.33 (0.325-0.355). Chelicera 0.215-0.22 (0.225-0.26) / 0.11-0.125 (0.125-0.14). Palp: trochanter 0.125-0.13 (0.13-0.14) / 0.08 (0.08-0.085); femur 0.265-0.27 (0.295) / 0.075-0.08 (0.08); patella 0.155-0.16 (0.175-0.18) / 0.095 (0.105); chela 0.41-0.42 (0.435-0.45) / 0.105-0.115 (0.12-0.125); hand 0.185-0.20 (0.21-0.215) / 0.11-0.12 (0.125); movable finger L 0.235-0.245 (0.25-0.26). Leg IV: femur+patella

0.295–0.31 (0.31–0.325) / 0.155–0.17 (0.16–0.18); tibia 0.19–0.21 (0.215–0.22) / 0.055–0.06 (0.06–0.065).

Material examined. Hawaii: Midway Is., Sand I., in Laysan albatross nest, 15-I-1964, C.F. Clagg, 1 female (mounted); Kauai I., Polihale Beach, behind sugar fields, litter under koahaole [*Leucaena leucocephala*], 7-VII-1981, M.L. Goff, 1 female; Oahu I., Honolulu, Punahou Square, litter under bamboo, 23-VI-1964, T. Suman, 1 male; Oahu I., Honolulu, Museum grounds, berlese of litter, 30-III-1964, W.J. Voss, 5 males, 6 females, 1 tritonymph, 1 deutonymph (4 m, 4 f mounted); all in BPBM.

Remarks. *L. sakagamii* is possibly a synonym of *L. asiatica* Redikorzev. According to published accounts (Redikorzev 1938; Morikawa 1952, 1960; Beier 1957) they are similar, but not enough information is available to allow a satisfactory comparison. Morikawa made no mention of Redikorzev's description of *L. asiatica*, either when he described *L. sakagamii* (1952) or in his review of Japanese pseudoscorpions (1960). Likewise, Beier did not mention *L. asiatica* when he recorded *L. sakagamii* from the Caroline Islands (1957), though he had previously acknowledged its presence in Vietnam (1951).

Little is known about the relationships of *Lechytia* species, in general, because few details are available for most of them. However, at least two distinct species groups can be recognized in the genus (Muchmore 1975; Judson 1992). *L. sakagamii* belongs to the "arborea group", with the following features: apical seta of palpal coxa bifid; chaetotaxy of 11th tergite is 1T2T1; cheliceral galea (spinneret) well developed in female, absent in male; most teeth of palpal chela much reduced. Other known representatives of the *arborea* group occur in southern United States and Mexico, and in the southern half of Africa (Judson 1992). *L. sakagamii* differs in significant respects from the "*hoffi* group", diagnosed by these features: apical seta of palpal coxa simple; chaetotaxy of 11th tergite is T2T; cheliceral galea well developed in both female and male; teeth of palpal chela relatively well developed. The *hoffi* group is presently known to include only *L. hoffi* Muchmore, from western United States. It would appear, then, that the ancestors of *L. sakagamii* came from eastern Asia, rather than from western North America.

Key to the Chthonioid Pseudoscorpions in Hawaii

1. Two trichobothria, transversely situated on dorsum of hand of palpal chela (Family Chthoniidae) 2
- Four trichobothria on dorsum of chelal hand, 2 placed transversely and 2 in tandem (Family Lechytidae) *Lechytia sakagamii*
- 2 (1) Coxal spines on coxae of legs II and III; bisetose intercoxal tubercle present *Chthonius tetrachelatus*
- Coxal spines on coxae of legs II only; no intercoxal tubercle 3
- 3 (2) Palpal chela with 1 slender, spinelike seta on medial side at base of fixed finger (Genus *Tyrannochthonius*) 4
- Palpal chela with 3 long, heavy, spinelike setae on medial side, 2 at base of hand and fixed finger and 1 at base of movable finger (Genus *Vulcanochthonius*) 7
- 4 (3) Large, slender species (palpal chela more than 1 mm in length, L/B greater than 6.3); from Maui, cavernicolous *Tyrannochthonius stonei*
- Smaller, less slender species (palpal chela less than 0.9 mm in length, L/B less than 5.7); 5

- 5 (4) Chela with more robust hand and relatively longer fingers (L/D of hand less than 1.75; movable finger more than 1.9x as long as hand); from Kauai, epigean *Tyrannochthonius swiftae*
 — Chela with more slender hand and relatively shorter fingers (L/D of hand more than 1.8; movable finger less than 1.9x as long as hand); from Oahu 6
- 6 (5) Appendages more slender (L/B of palpal femur = 4.8–5.15, L/D of leg IV femur+patella = 2.8–2.9); eyes small and faint; cavernicolous. *Tyrannochthonius pupukeanus*
 — Appendages less slender (L/B of palpal femur = 4.65–4.75, leg IV femur+patella = 2.4–2.65); eyes well developed, corneate; epigean. *Tyrannochthonius oahuanus*
- 7 (3) Smaller, less slender species (palpal chela L less than 0.9 mm, L/B less than 5.5), with 4 eyes *Vulcanochthonius aa*
 — Larger, more slender species (palpal chela L about 1 mm, L/B greater than 6.5), with 2 eyes 8
- 8 (7) Movable chelal finger 2.03x as long as hand; chela L = 1.13 mm, L/B = 7.3 *Vulcanochthonius pohakuloae*
 — Movable chelal finger 1.75–1.8x as long as hand; chela L = 0.96–1.04 mm, L/B = 6.6–6.7 *Vulcanochthonius howarthi*

Discussion

The Hawaiian fauna of chthonioid pseudoscorpions, nine in number, appear diverse in their origins. One species is a cosmopolitan synanthrope, one is a species widespread in the western Pacific area, and the other seven seem to be endemic.

Chthonius tetrachelatus is known from many parts of the world, and it is not surprising to find it here, probably brought to the islands in soil accompanying agricultural materials.

Lechytia sakagami has been reported from a number of islands in the Pacific Ocean, from the Carolines to Hawaii. It is likely phoretic on sea birds (it was found in an albatross nest on Midway I.) and perhaps has also been transported by humans.

The four species of *Tyrannochthonius* all appear to be distinct from other known representatives of the genus in the Pacific area. The two cavernicolous species, *T. pupukeanus* and *T. stonei*, are surely endemic. One or both of the epigean forms, *T. swiftae* and *T. oahuanus*, may represent the original founder(s) or may be derived species. Much more information about the *Tyrannochthonius* fauna of the Pacific islands is needed before these questions can be resolved.

The three species of *Vulcanochthonius* are certainly endemic, having evolved on the volcanoes of Hawaii Island from an as yet unidentified, tyrannochthoniine ancestor.

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